
Interactive Data Visualization: A Tool for Common Clinical Study Figures and SAP Figure Shells

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Agenda

- Introduction
- User Interface and Workflow
- Behind the Scenes: Use VBA to Generate SAS Program
- Feature Highlight: Interactive Visualization
- Sample Figure Library
- How This Tool Help Figure Shell and Analysis
- Conclusion

Introduction

- Figures are unique and essential in clinical study data reporting.
- At the planning stage, statisticians need to produce figure shells for the Statistical Analysis Plan (SAP).

How



Figure Shell with Text Only

Figure 15.3.1.5
Box Plot of Liver Function Tests
Safety Population, Part 1
Parameter: Alanine Aminotransferase (U/L)

Note: The bottom/top of each box represent the 25th/75th percentiles, respectively. The whiskers of each box represent the 10th/90th percentiles, the horizontal line within each box represents the median, and the line chart represents the mean.

[Programming Note]

Y axis: Alanine Aminotransferase (U/L)

X axis: Study Visits

Placebo Group: Blue color

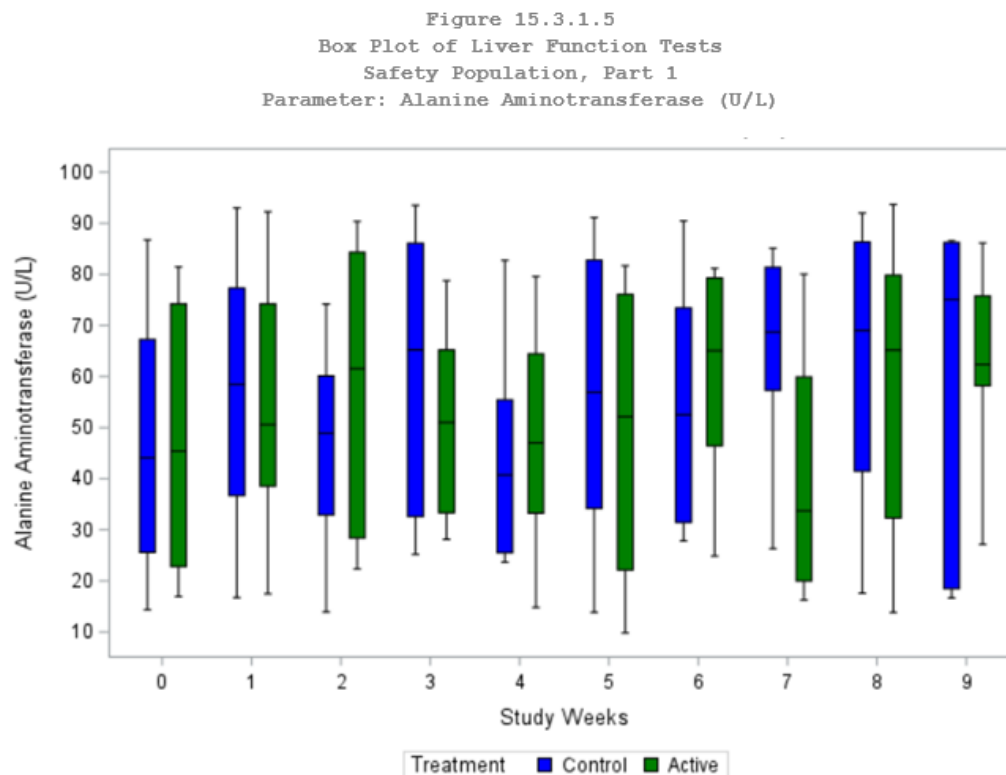
Active Group: Red color

Display data for all planned visits.

Add a line plot to connect the mean values in addition to the box plot.

Repeat for parameter Aspartate Aminotransferase (U/L).

Figure Shell with Sample From Other Study



Note: The bottom/top of each box represent the 25th/75th percentiles, respectively. The whiskers of each box represent the 10th/90th percentiles, the horizontal line within each box represents the median, and the line chart represents the mean.

[Programming Note]

Change X axis to: Study Visits, display data for all planned visits.

Use Treatment groups 'Placebo' (Blue) and 'Active' (red)

Add a line plot to connect the mean values in addition to the box plot.

Repeat for parameter Aspartate Aminotransferase (U/L).

User Interface

	CreateSAS	GRPN	GRP	XAXIS	AVISIT	SUBJID	AVAL
		1	Placebo	0	Visit0	subject1	69.58725952
		1	Placebo	1	Visit1	subject1	54.78350426
		1	Placebo	2	Visit2	subject1	94.00402323
		1	Placebo	3	Visit3	subject1	86.01699959
		1	Placebo	4	Visit4	subject1	32.25982649
		1	Placebo	5	Visit5	subject1	10.64659983
		1	Placebo	6	Visit6	subject1	33.35206467
		1	Placebo	7	Visit7	subject1	71.51830263
		1	Placebo	8	Visit8	subject1	68.99222199
Program Name	Line_plot.sas	2	Active	0	Visit0	subject1	44.18230896
Title1	Figure 15.3.1.4	2	Active	1	Visit1	subject1	39.02700043
Title2	Mean ($\pm$ SE) of Liver Function Tests	2	Active	2	Visit2	subject1	28.36096957
Title3	Safety Population	2	Active	3	Visit3	subject1	57.06303083
Title4	Parameter: Alanine Aminotransferase (U/L)	2	Active	4	Visit4	subject1	49.81380613
xlabel	Study Visits	1	Placebo	0	Visit0	subject2	28.63763025
ylabel	Alanine Aminotransferase (U/L)	1	Placebo	1	Visit1	subject2	74.10678884
legendlabel	Treatment	2	Active	0	Visit0	subject2	17.74684439
legendooption	location=inside valign=bottom border=false	2	Active	1	Visit1	subject2	82.09512845
Colors	blue red green	2	Active	2	Visit2	subject2	84.25153311
Symbols	CircleFilled TriangleFilled Triangle	2	Active	3	Visit3	subject2	39.44259654
xtick	(0 1 2 3 4 5 6 7 8 9 10 11)	1	Placebo	0	Visit0	subject3	94.95361337
ytick	(10 20 30 40 50 60 70 80 90 100)	1	Placebo	1	Visit1	subject3	65.25623591
		1	Placebo	2	Visit2	subject3	68.26368227
		1	Placebo	3	Visit3	subject3	31.02560933
		1	Placebo	4	Visit4	subject3	42.29118724
		1	Placebo	5	Visit5	subject3	27.7320462
		1	Placebo	6	Visit6	subject3	27.85536921
		1	Placebo	7	Visit7	subject3	94.57521177
		1	Placebo	8	Visit8	subject3	41.44087346
		1	Placebo	9	Visit9	subject3	18.44607918
		1	Placebo	10	Visit10	subject3	23.57574898
		1	Placebo	11	Visit11	subject3	55.80207708
		2	Active	0	Visit0	subject3	60.06465837
►	TOC	LinePlot	LineData	BoxPlot	BoxData	ScatterPlot	►
		TOC	LinePlot	LineData	BoxPlot	BoxData	

a. Attributes Tab

b. Data Tab

Sample Output SAS Code (1)

- a. ➤ Read in attribute tab information
- Set as macro variables to use later

```
%let title1 = Figure 15.3.1.4;  
%let title2 = Mean ( $\pm$  SE) of Liver Function Tests;  
%let title3 = Safety Population;  
%let title4 = Parameter: Alanine Aminotransferase (U/L);  
%let xlabel = Study Visits;  
%let ylabel = Alanine Aminotransferase (U/L);  
%let legendlabel = Treatment;  
%let legendoption = location=inside halign=left valign=bottom border=false;  
%let colors = blue|red|green;  
%let symbols = CircleFilled|TriangleFilled|Triangle;  
%let xtick = (0 1 2 3 4 5 6 7 8 9 10 11);  
%let ytick = (10 20 30 40 50 60 70 80 90 100);
```

Sample Output SAS Code (2)

- b. ➤ Read in data tab information (partially shown)

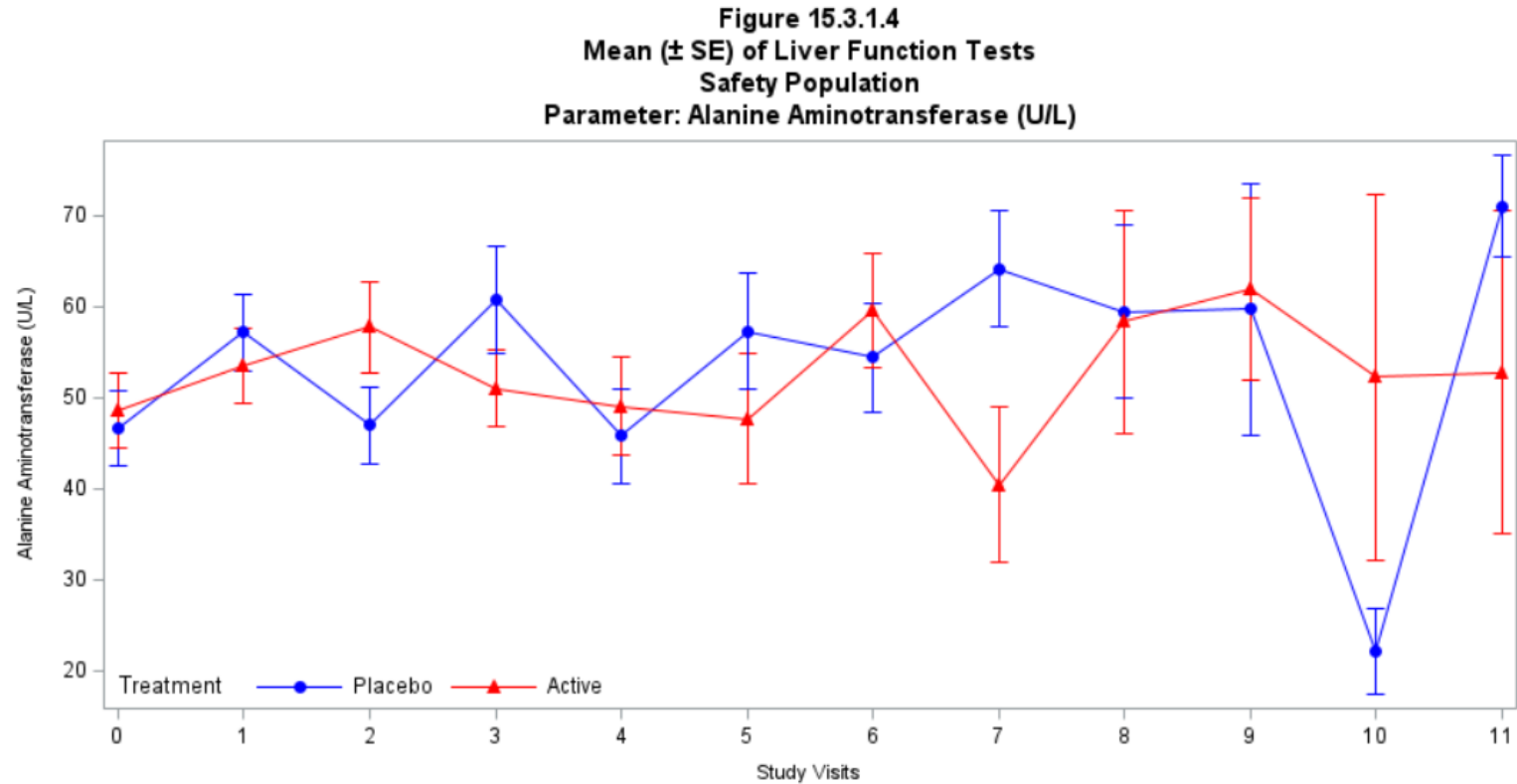
```
data final;
  length GRP $200.;
  length AVISIT $200.;
  length SUBJID $200.;
  GRPN=1; GRP="Placebo"; XAXIS=0; AVISIT="Visit0"; SUBJID="subject1"; AVAL=69.5872595231049; output;
  GRPN=1; GRP="Placebo"; XAXIS=1; AVISIT="Visit1"; SUBJID="subject1"; AVAL=54.7835042630322; output;
  GRPN=1; GRP="Placebo"; XAXIS=2; AVISIT="Visit2"; SUBJID="subject1"; AVAL=94.0040232324973; output;
  GRPN=1; GRP="Placebo"; XAXIS=3; AVISIT="Visit3"; SUBJID="subject1"; AVAL=86.0169995897449; output;
```

Sample Output SAS Code (3)

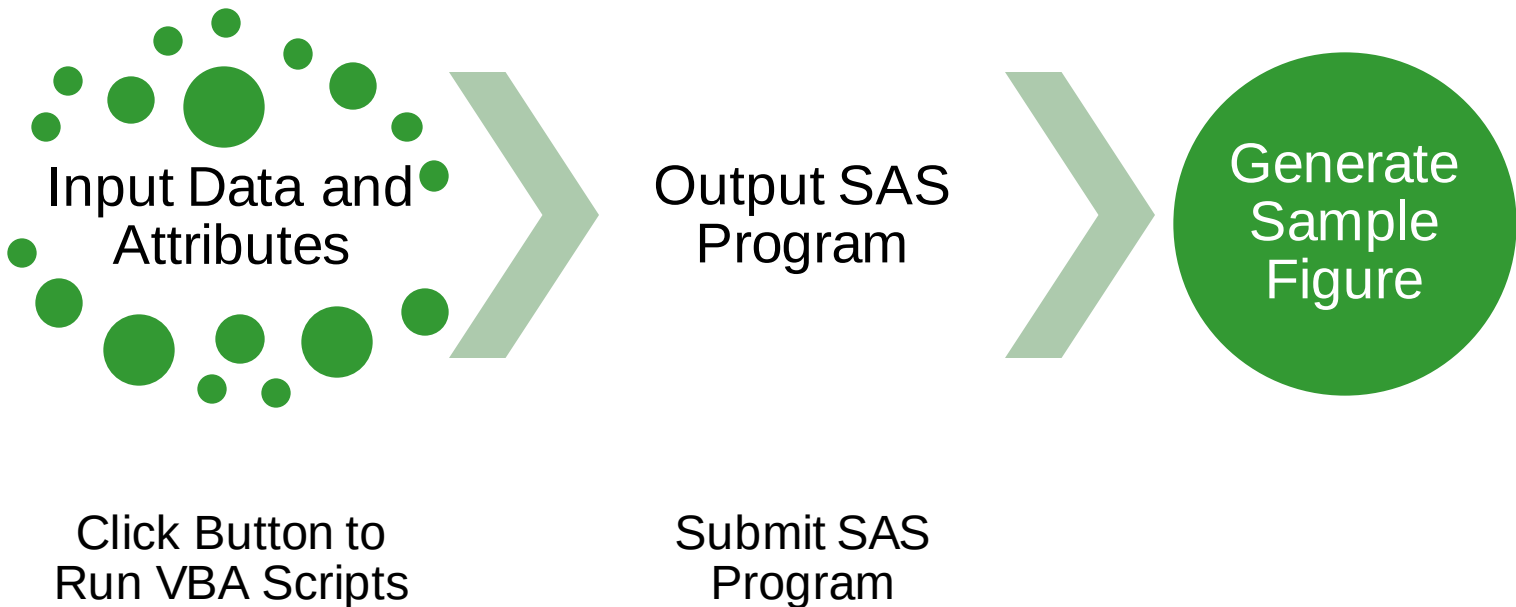
- C. ➤ Post-processing of the data
➤ Plot procedure

```
proc sort data = final; by grpn grp xaxis avisit; run;
proc univariate data = final noprint;
  by grpn grp xaxis avisit;
  var aval;
  output out=final2 mean=yaxis stdmean=interval;
run;
data final3; set final2; yaxisl=yaxis-interval; yaxish=yaxis+interval; run;
proc sort data = final2(wher=(grpn > .)) out = grps nodupkey; by grpn; run;
data _null_;
  set grps end=eof;
  call symput ('grps' || compress(put(_n_,best12.), trim(put(grp,$100.))));
  if eof then call symput('tot_grp', compress(put(_n_, best12.)));
run;
%macro mcl;
proc template;
  define statgraph LinePlot;
    dynamic TITLE1 TITLE2 TITLE3 TITLE4 TITLE5;
    begingraph / border=false designwidth=9in designheight=4.8in;
      discreteattrmap name="grp" / ignorecase=true;
      %do i = 1 %to &tot_grp.;
        value "&grps&i.." / markerattrs=GraphData&i(color=%scan(&colors, &i,|) symbol=%scan(&symbols, &i,|) size=7)
        |lineattrs=GraphData&i(color=%scan(&colors, &i,|) fillattrs=(color=%scan(&colors, &i,|) textattrs=(color=%scan(&colors, &i,|));
      %end;
    enddiscreteattrmap;
    discreteattrvar attrvar=grp var=grp attrmap="grp";
    entrytitle TITLE1; entrytitle TITLE2; entrytitle TITLE3; entrytitle TITLE4; entrytitle TITLE5;
    layout overlay /
      xaxisopts=(LABELATTRS=(SIZE=8pt) label="%xlabel." type=linear linearopts=(tickvaluelist=%xtick. tickvaluefitpolicy=rotate ))
      yaxisopts=(LABELATTRS=(SIZE=8pt) label="%ylabel." linearopts=(tickvaluelist=%ytick. ));
      seriesplot x=xaxis y=yaxis / group=grp name='a' includemissinggroup=false;
      scatterplot x=xaxis y=yaxis / group=grp name='b' YerrorLower=yaxisl YerrorUpper=yaxish ;
      MERGEDLEGEND 'a' 'b' / title="%legendlabel." down=2 &legendoption.;
    endlayout;
  endgraph;
end;
run;
%mend mcl; %mcl;
proc sgrender data=final3 template=LinePlot;
  dynamic TITLE1="%title1" TITLE2="%title2" TITLE3="%title3" TITLE4="%title4";
run;
```

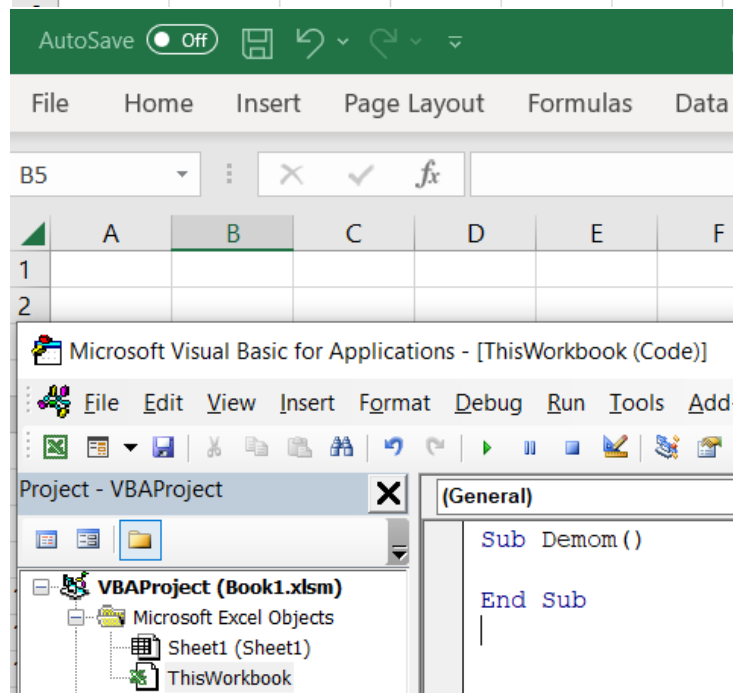
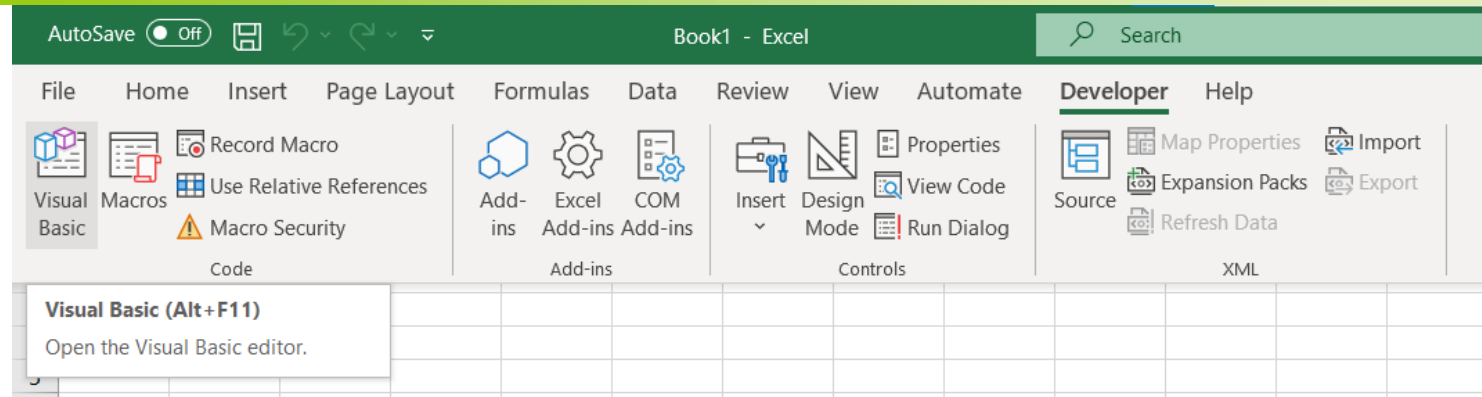
Sample Output Line Plot



Workflow Summary

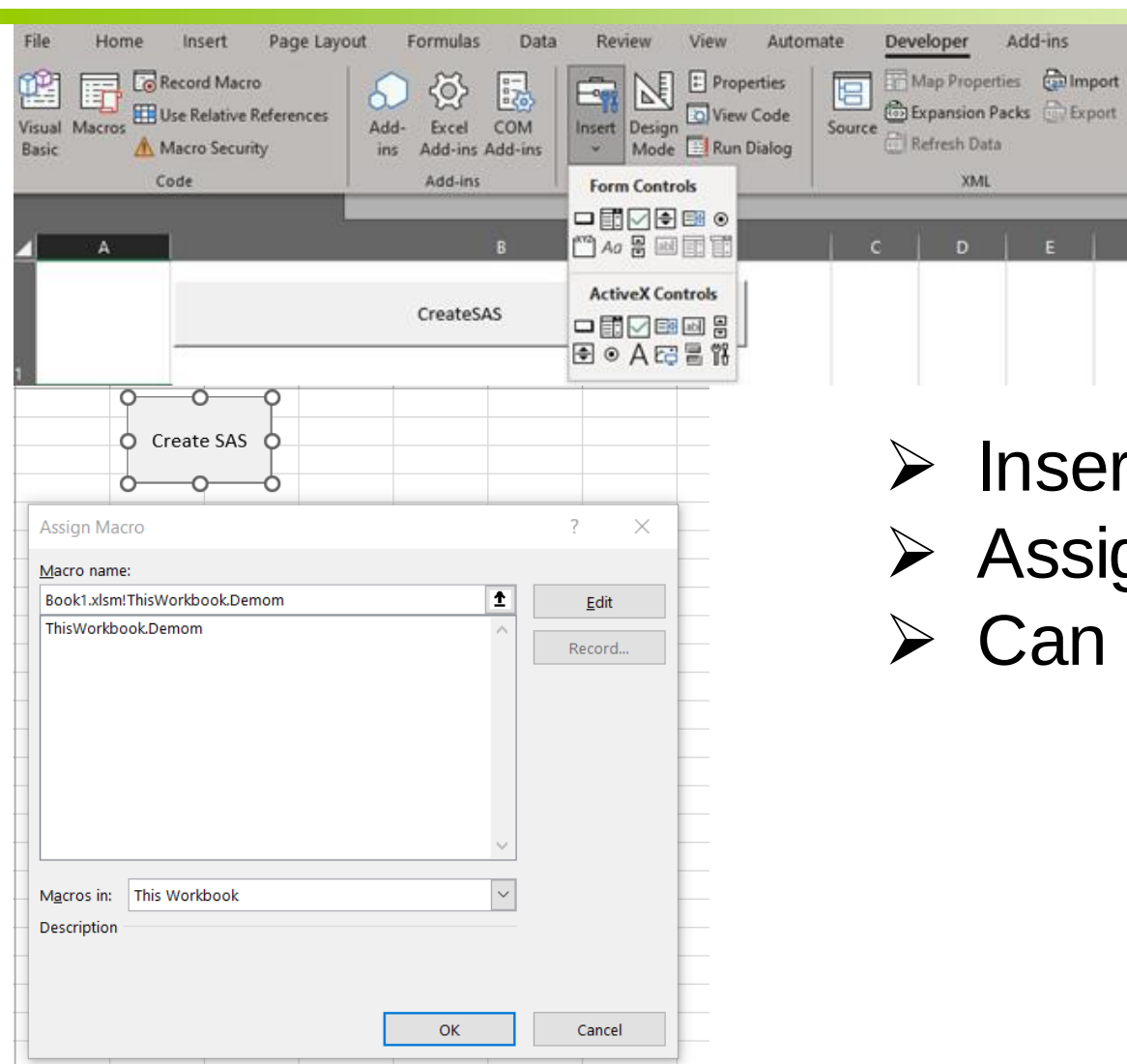


Initiate VBA Macro



- Open VBA Editor
- Initiate Macro Demom

Insert Button



- Insert a Button
- Assign Macro
- Can Edit Text

Read Attributes Tab (1)

➤ Find Column

With

ActiveSheet.Buttons (Application.Caller).TopLeftCell

ProgCol = .Column

End With

➤ Find Row

Rowa = Cells.Find(What:="Program Name",

After:=ActiveSheet.Cells(1, 1), LookAt:=xlPart,

LookIn:=xlValues, SearchOrder:=xlByRows,

SearchDirection:=xlPrevious, MatchCase:=False).Row

Read Attributes Tab (2)

➤ Current Path and SAS Output Name

```
Set pgm = Cells(RowA, ProgCol)
path = ThisWorkbook.path & "\" & pgm
Open path For Output As FileNum
```

➤ Print SAS Output

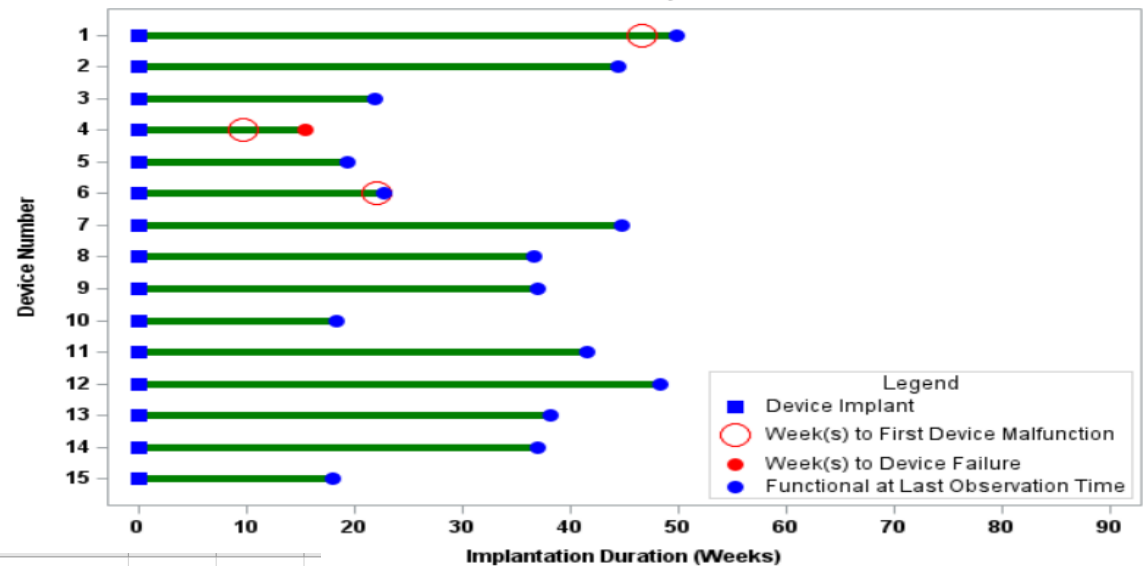
```
Print #FileNum, "%let title1 = " & title1 & ";"
(Replace all double quotation marks with 'Chr(34)')
```

Read Data Tab

- 'Activate' data tab
- Find number of columns and rows
- Detect data type, set variable length
- Read through each row of data.
- Sample VBA scripts for this part can be found in paper Appendix 1.

Interactive Visualization: Adjusting Attributes

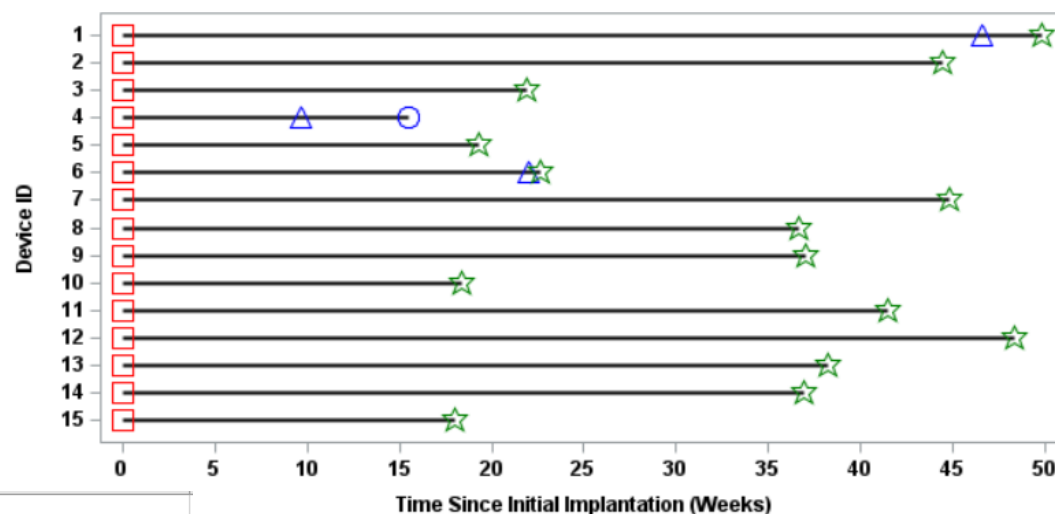
Figure 3.1.1
Time (Weeks) from Device Implantation to Failure/Continuing Function by Device
All Devices Implanted



	CreateSAS		
Program Name	Swimmer_plot.sas		
Title1	Figure 3.1.1		
Title2	Time (Weeks) from Device Implantation to Failure/Continuing Function by Device		
Title3	All Devices Implanted		
xlabel	Implantation Duration (Weeks)		
ylabel	Device Number		
legendlabel	Legend		
legendooption	border=on valign=bottom halign=right location=inside		
xtickvalue	xmin=0 xmax=90 xtick=10		
x1attr	SYMBOL=squarefilled size=8pt color=blue		
x2attr	SYMBOL=circle size=13pt color=red		
x3attr	SYMBOL=circlefilled size=8pt color=red		
x4attr	SYMBOL=circlefilled size=8pt color=blue		
lineattr	color=green thickness=4pt		

Interactive Visualization: Adjusting Attributes

Figure 3.1.1.1
Device Events
All Devices

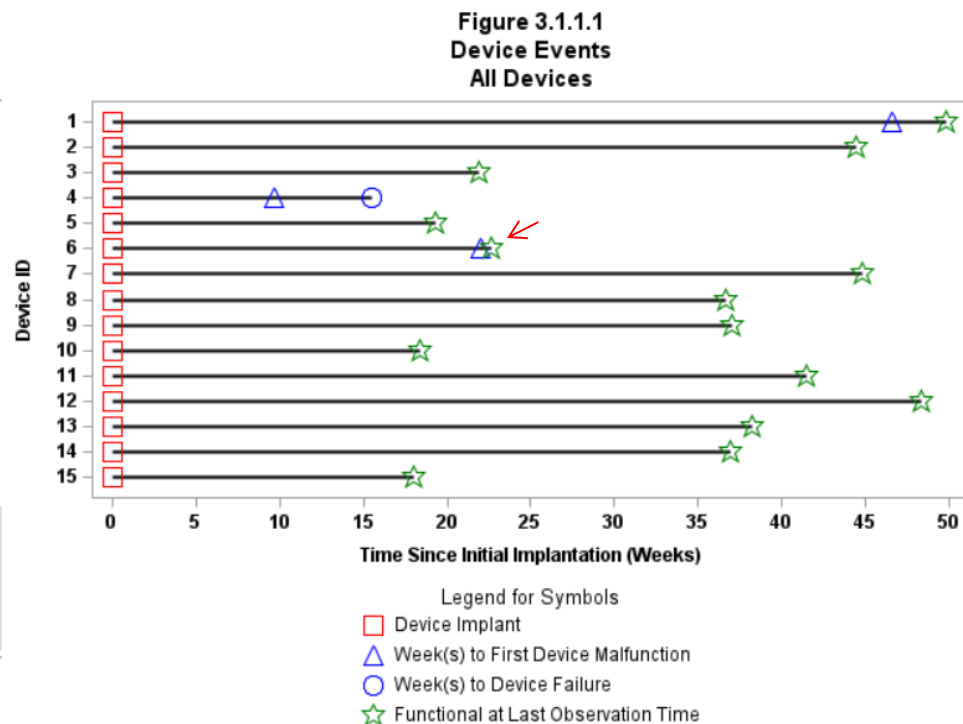
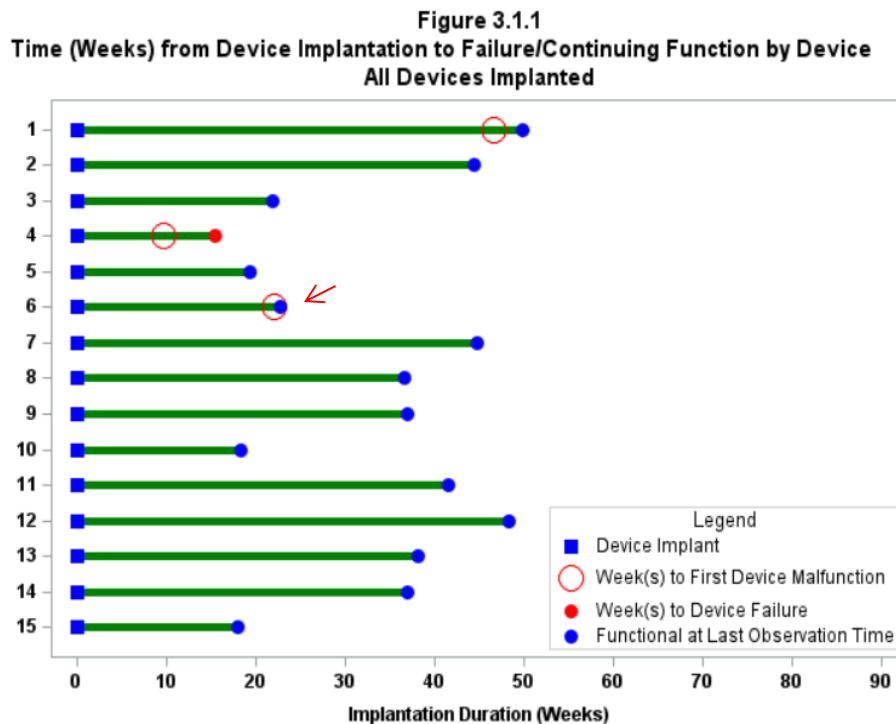


Legend for Symbols

- Device Implant
- △ Week(s) to First Device Malfunction
- Week(s) to Device Failure
- ☆ Functional at Last Observation Time

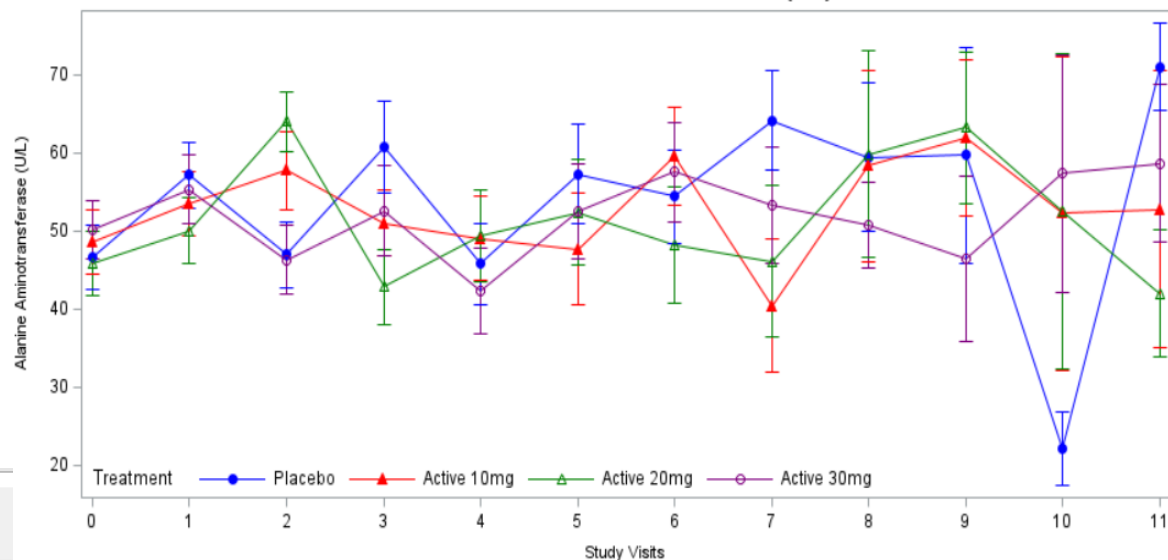
	CreateSAS
Program Name	Swimmer_plot2.sas
Title1	Figure 3.1.1.1
Title2	Device Events
Title3	All Devices
xlabel	Time Since Initial Implantation (Weeks)
ylabel	Device ID
legendlabel	Legend for Symbols
legendooption	border=off valign=bottom halign=center location=outside
xtickvalue	xmin=0 xmax=50 xtick=5
x1attr	SYMBOL=square size=10pt color=red
x2attr	SYMBOL=triangle size=10pt color=blue
x3attr	SYMBOL=circle size=10pt color=blue
x4attr	SYMBOL=star size=10pt color=green
lineattr	color=black thickness=2pt

Interactive Visualization: Adjusting Attributes



Interactive Visualization: Adjusting Data

Figure 15.3.1.4.1
Mean ($\pm$ SE) of Liver Function Tests
Safety Population
Parameter: Alanine Aminotransferase (U/L)



	CreateSAS
Program Name	Line_plot2.sas
Title1	Figure 15.3.1.4.1
Title2	Mean ($\pm$ SE) of Liver Function Tests
Title3	Safety Population
Title4	Parameter: Alanine Aminotransferase (U/L)
xlabel	Study Visits
ylabel	Alanine Aminotransferase (U/L)
legendlabel	Treatment
legendoption	location=inside haln=left valign=bottom border=false
Colors	blue red green purple
Symbols	CircleFilled TriangleFilled Triangle Circle
xtick	(0 1 2 3 4 5 6 7 8 9 10 11)
ytick	(10 20 30 40 50 60 70 80 90 100)

Sample Figure Library: TOC

Table of Contents

[Line Plot](#)

[Box Plot](#)

[Scatter Plot](#)

[KM Plot](#)

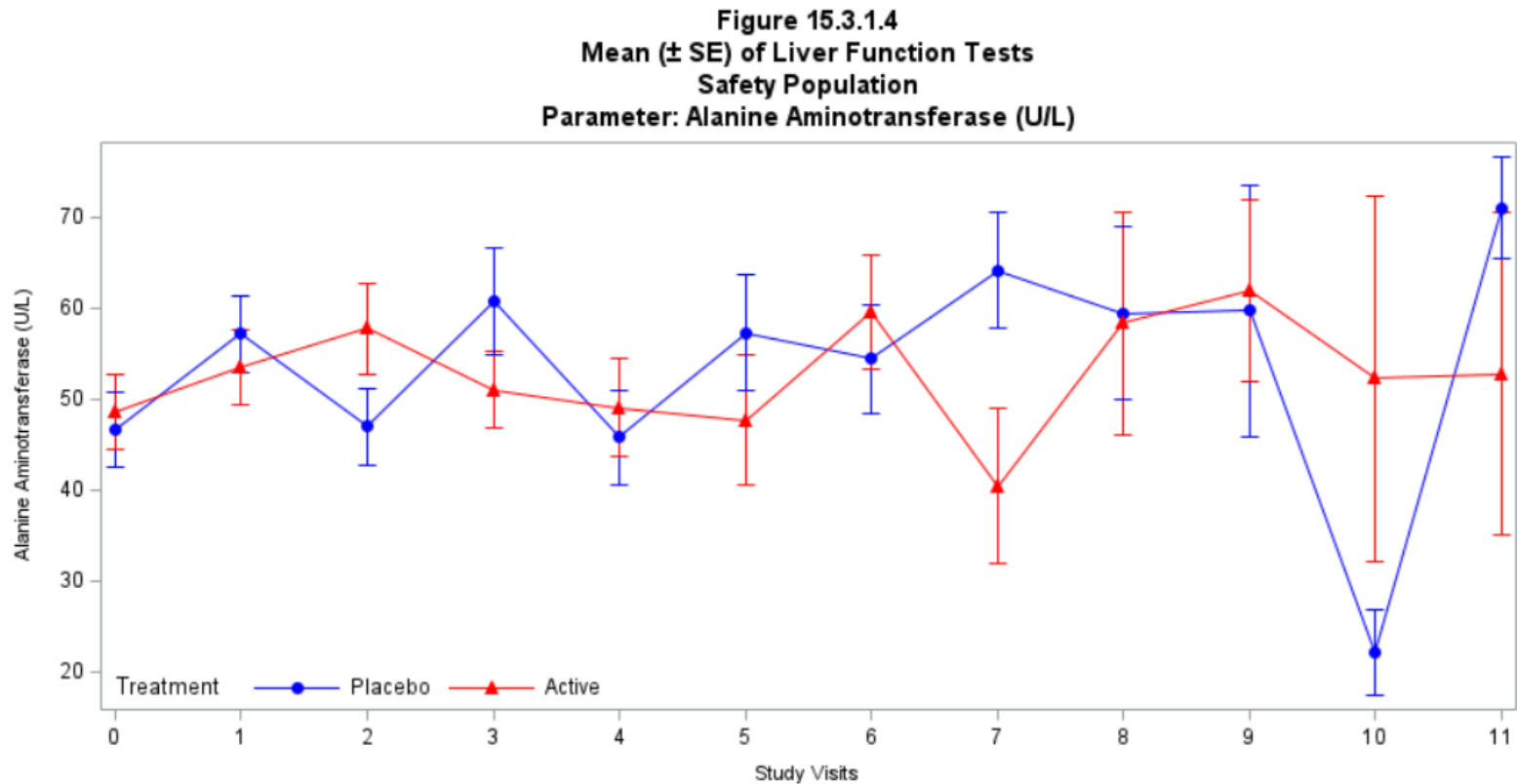
[Forest Plot](#)

[Waterfall Plot](#)

[Swimmer Plot](#)

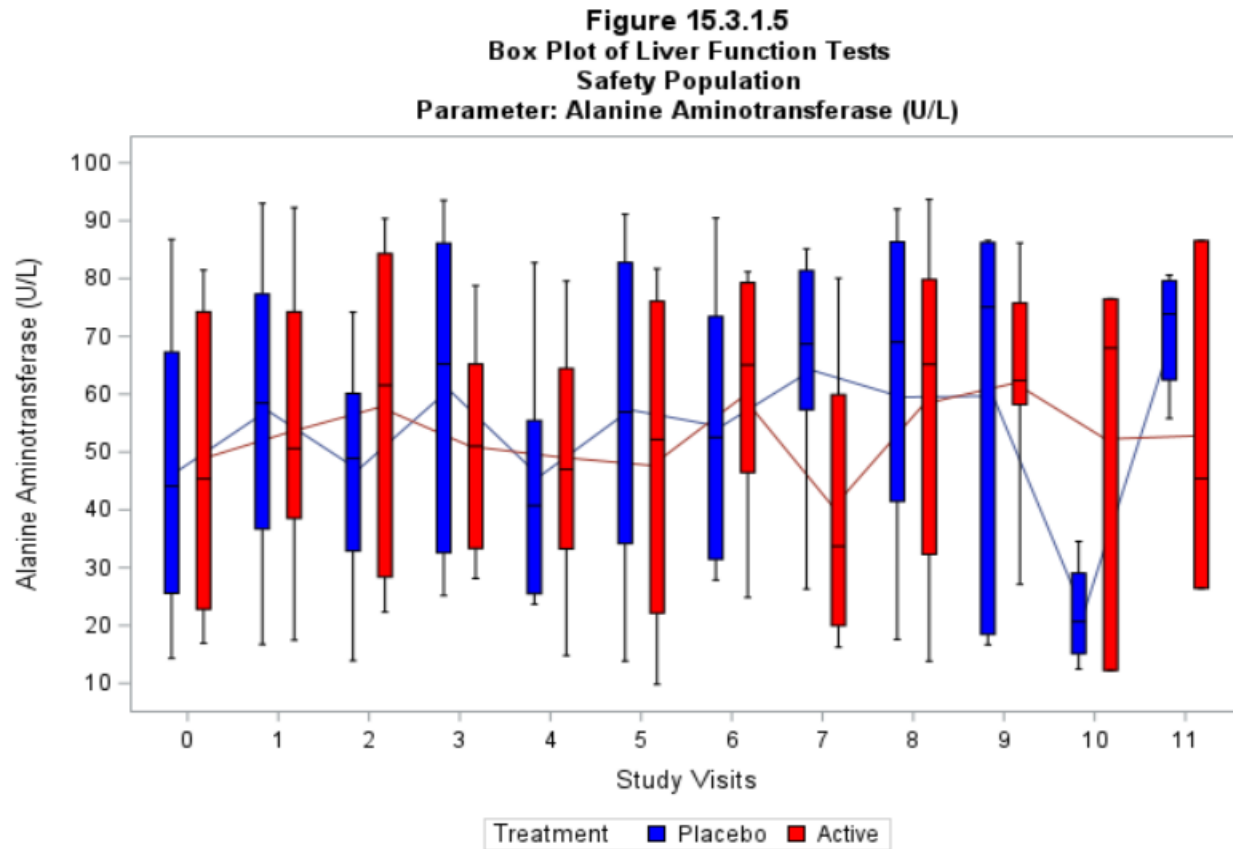
[Heatmap](#)

Repeated Measures Plot (1)

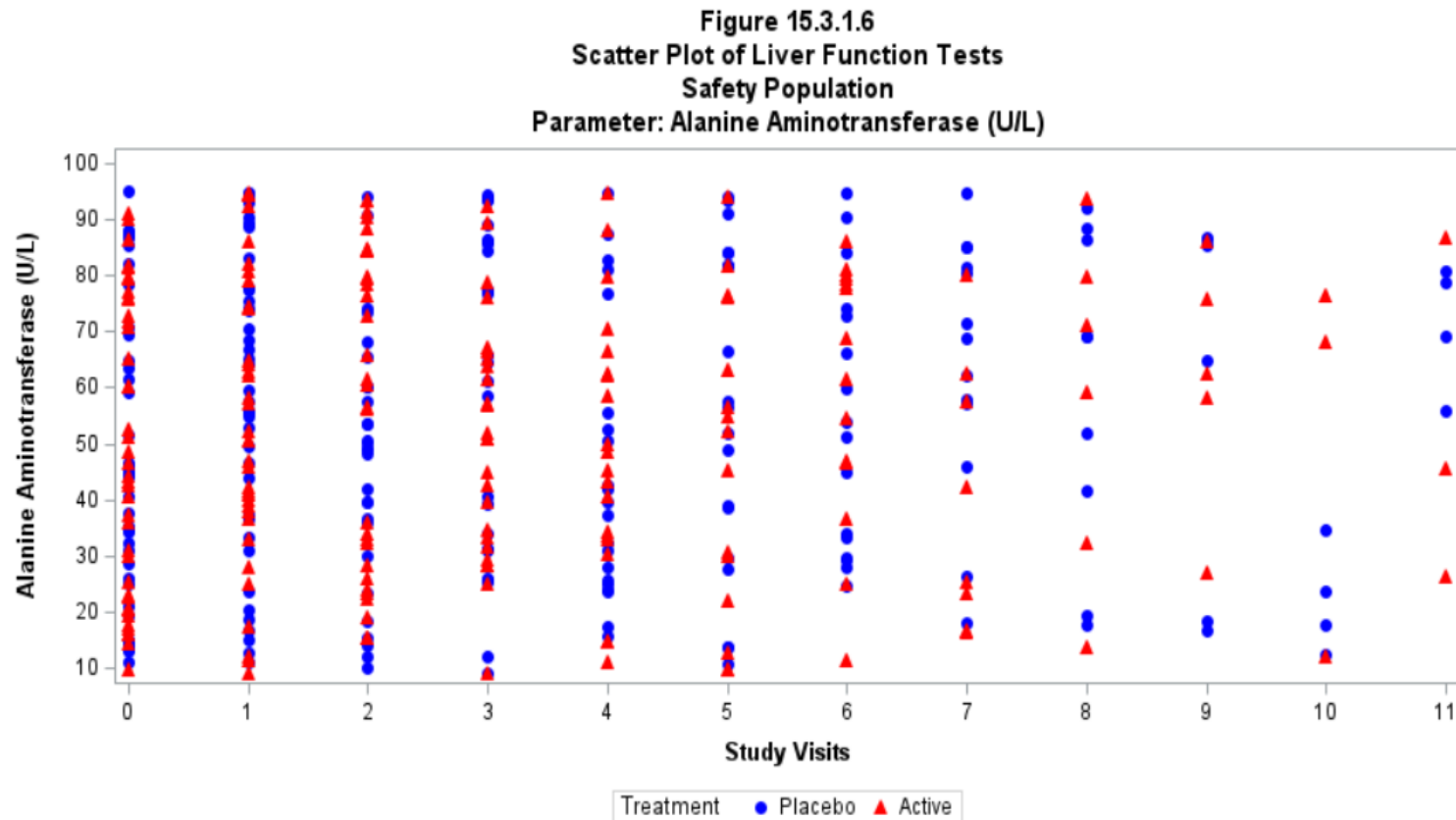


- Repeated measures plots are one of the most common types in clinical data reports [1]

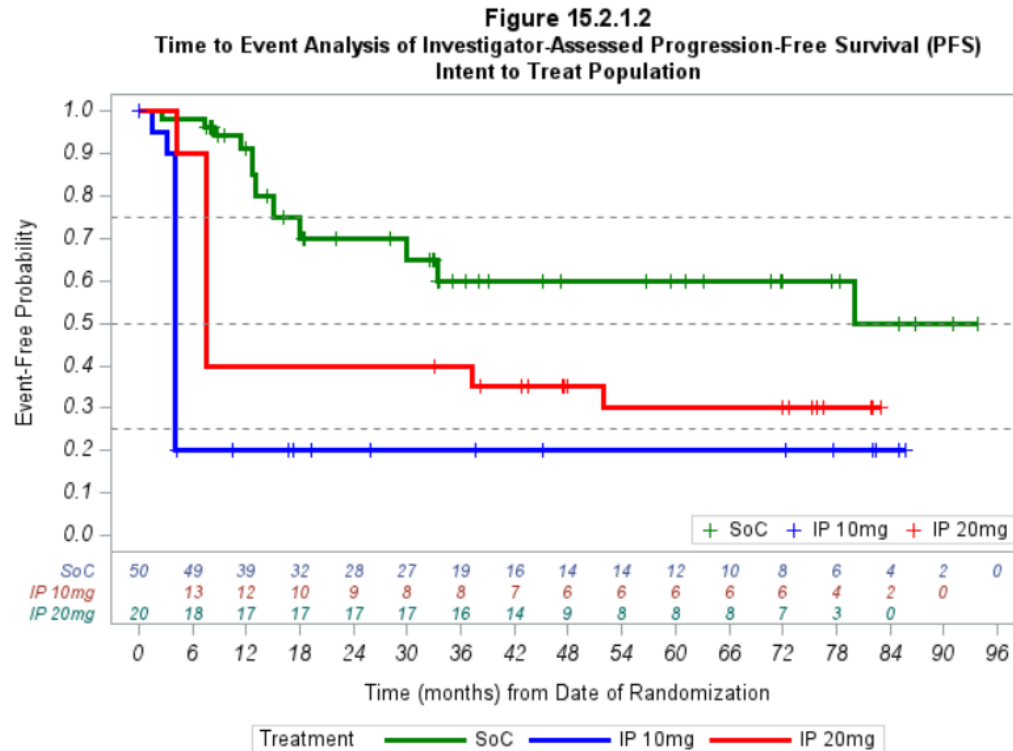
Repeated Measures Plot (2)



Repeated Measures Plot (3)



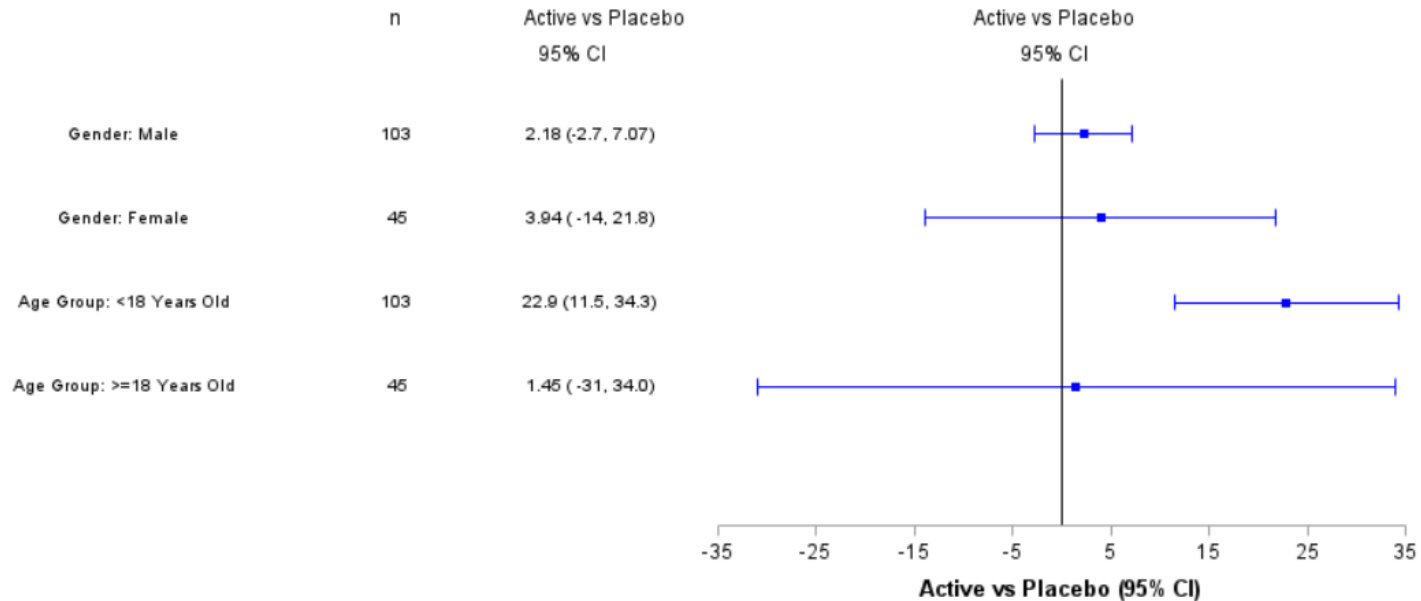
Kaplan-Meier Plot



- Kaplan-Meier plot for time-to-event analysis

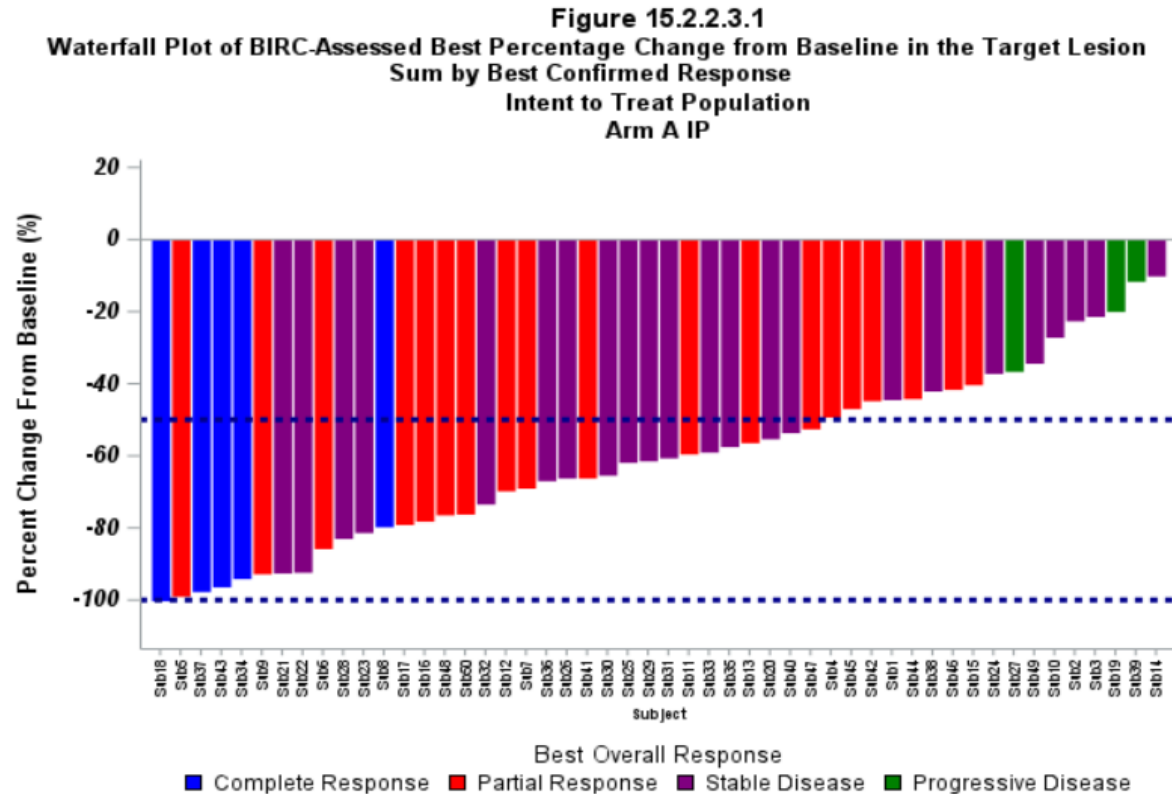
Forest Plot

Figure 15.2.2.5.1
Forest Plot for Treatment Difference in Standard Scores at Visit Week 52 by Subgroups
Intent to Treat Population



- Forest plot for subgroup analysis
- Both are most common types used in clinical data reports [1]

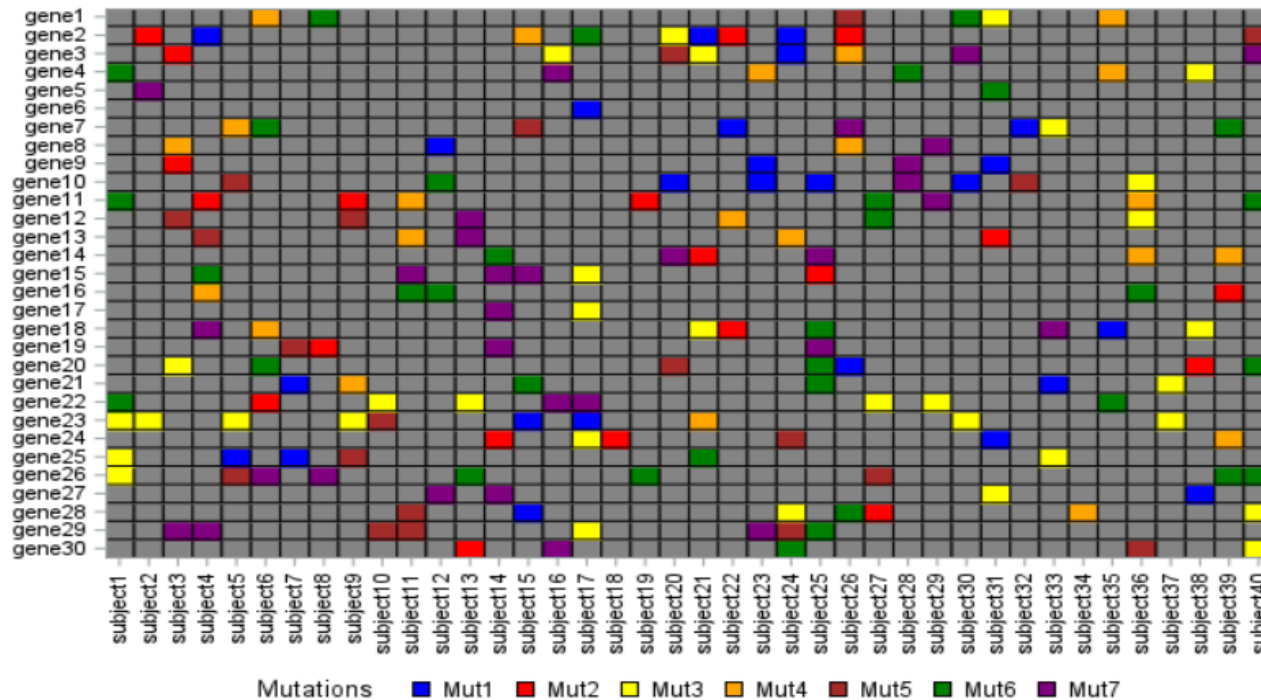
Waterfall Plot



- Waterfall plots, together with swimmer plots shown earlier, are common graphs to visualize each individual patient's response to tumor interventions [2,3,4].

Heatmap

Figure 15.3.2.1
Heatmap of Mutations in Genes by Subject at Baseline
Safety Population



- Heatmaps are powerful in mapping cancer genotypes and phenotypes [3]. They can also be used to represent adverse events by treatment, metabolic abnormalities, infection rate in different populations, etc. [5]

Choose the Right Figure Type

Figure 15.3.1.4
Mean ($\pm$ SE) of Liver Function Tests
Safety Population
Parameter: Alanine Aminotransferase (U/L)

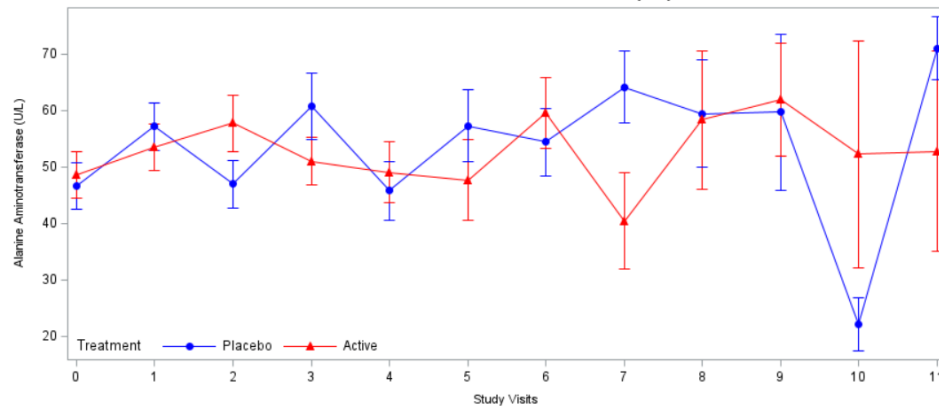


Figure 15.3.1.6
Scatter Plot of Liver Function Tests
Safety Population
Parameter: Alanine Aminotransferase (U/L)

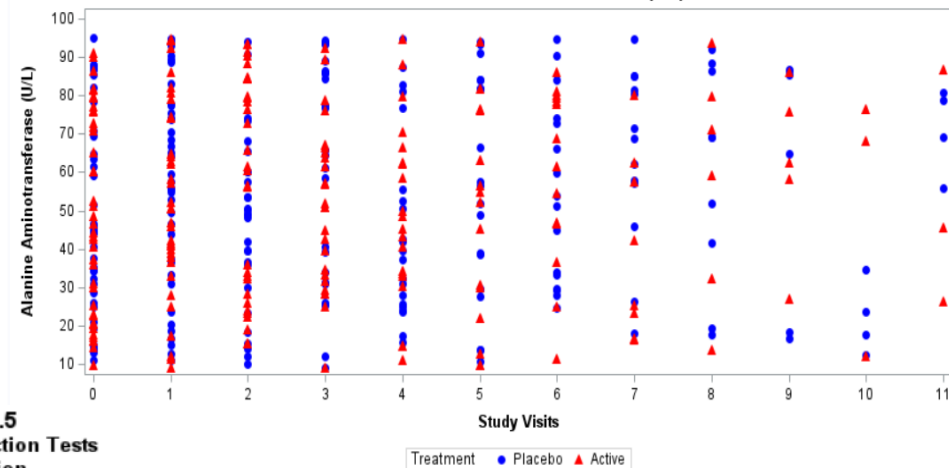
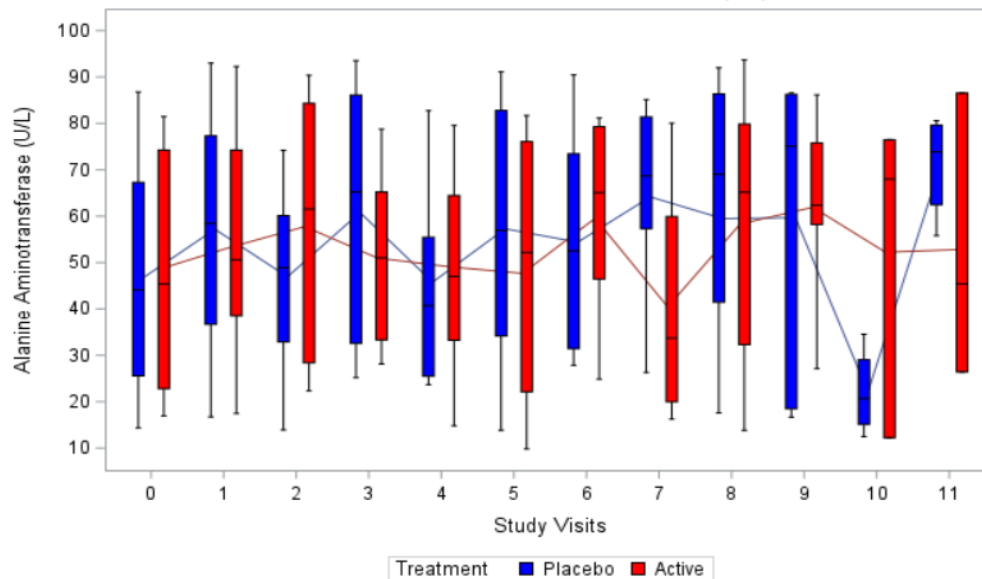
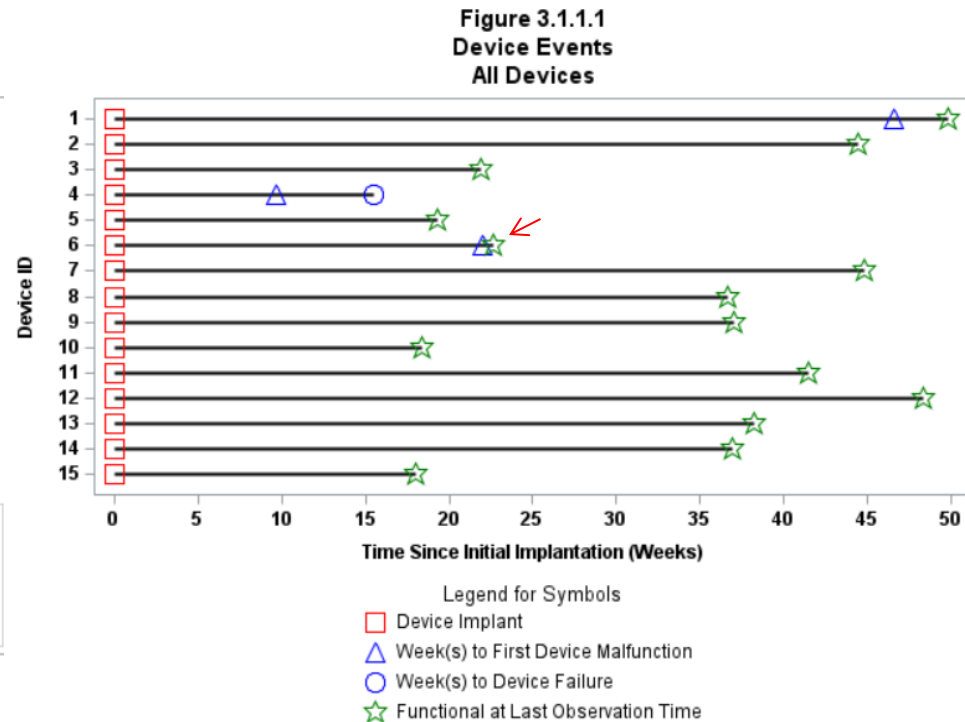
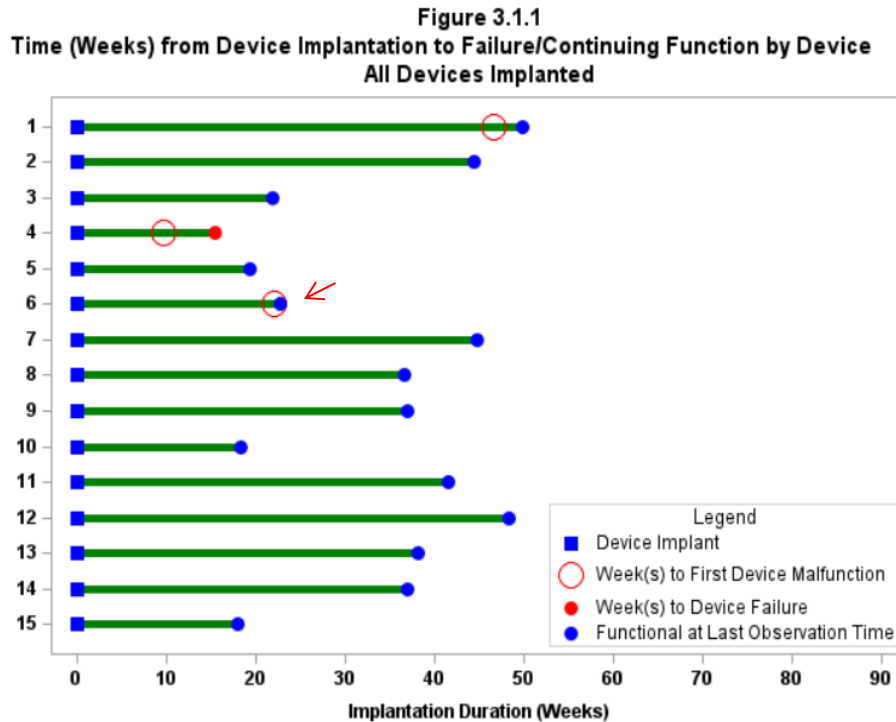


Figure 15.3.1.5
Box Plot of Liver Function Tests
Safety Population
Parameter: Alanine Aminotransferase (U/L)



Decide on the Details



Convey the Information in the Figure Shells-Old

Figure 15.3.1.5
Box Plot of Liver Function Tests
Safety Population, Part 1
Parameter: Alanine Aminotransferase (U/L)

Note: The bottom/top of each box represent the 25th/75th percentiles, respectively. The whiskers of each box represent the 10th/90th percentiles, the horizontal line within each box represents the median, and the line chart represents the mean.

[Programming Note]

Y axis: Alanine Aminotransferase (U/L)

X axis: Study Visits

Placebo Group: Blue color

Active Group: Red color

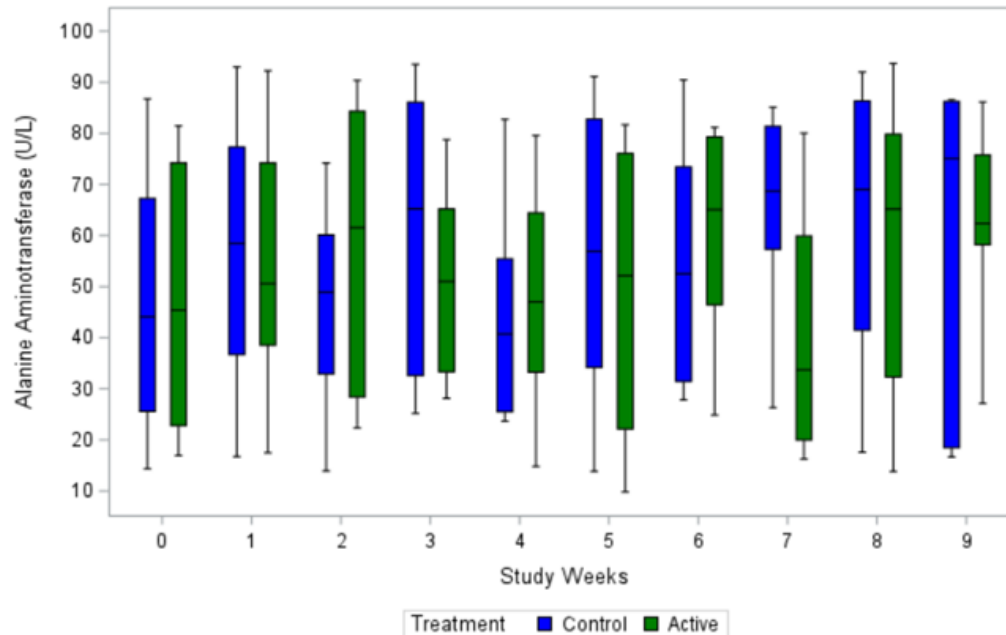
Display data for all planned visits.

Add a line plot to connect the mean values in addition to the box plot.

Repeat for parameter Aspartate Aminotransferase (U/L).

Convey the Information in the Figure Shells-Old

Figure 15.3.1.5
Box Plot of Liver Function Tests
Safety Population, Part 1
Parameter: Alanine Aminotransferase (U/L)



Note: The bottom/top of each box represent the 25th/75th percentiles, respectively. The whiskers of each box represent the 10th/90th percentiles, the horizontal line within each box represents the median, and the line chart represents the mean.

[Programming Note]

Change X axis to: Study Visits, display data for all planned visits.

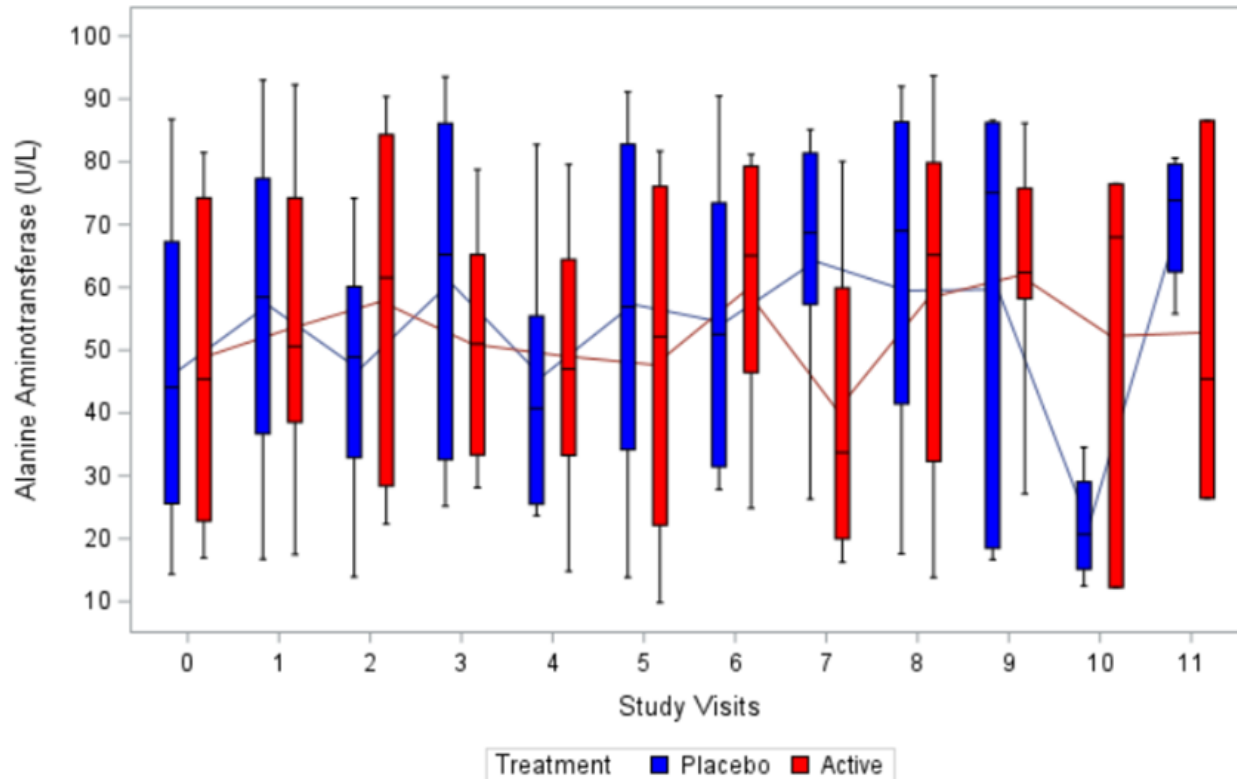
Use Treatment groups 'Placebo' (Blue) and 'Active' (red)

Add a line plot to connect the mean values in addition to the box plot.

Repeat for parameter Aspartate Aminotransferase (U/L).

Convey the Information in the Figure Shells-New

Figure 15.3.1.5
Box Plot of Liver Function Tests
Safety Population, Part 1
Parameter: Alanine Aminotransferase (U/L)



Note: The bottom/top of each box represent the 25th/75th percentiles, respectively. The whiskers of each box represent the 10th/90th percentiles, the horizontal line within each box represents the median, and the line chart represents the mean.

[Programming Note] Repeat for parameter Aspartate Aminotransferase (U/L).

Reuse SAS Code to Facilitate Analysis

```

%let title1 = Figure 15.3.1.4;
%let title2 = Mean ( $\pm$  SE) of Liver Function Tests;
%let title3 = Safety Population;
%let title4 = Parameter: Alanine Aminotransferase (U/L);
%let xlabel = Study Visits;
%let ylabel = Alanine Aminotransferase (U/L);
%let legendlabel = Treatment;
%let legendoption = location=inside halign=left valign=bottom border=false;
%let colors = blue|red|green;
%let symbols = CircleFilled|TriangleFilled|Triangle;
%let xtick = (1 2 3 4 5 6 7 8 9 10 11 12);
%let ytick = (10 20 30 40 50 60 70 80 90 100);

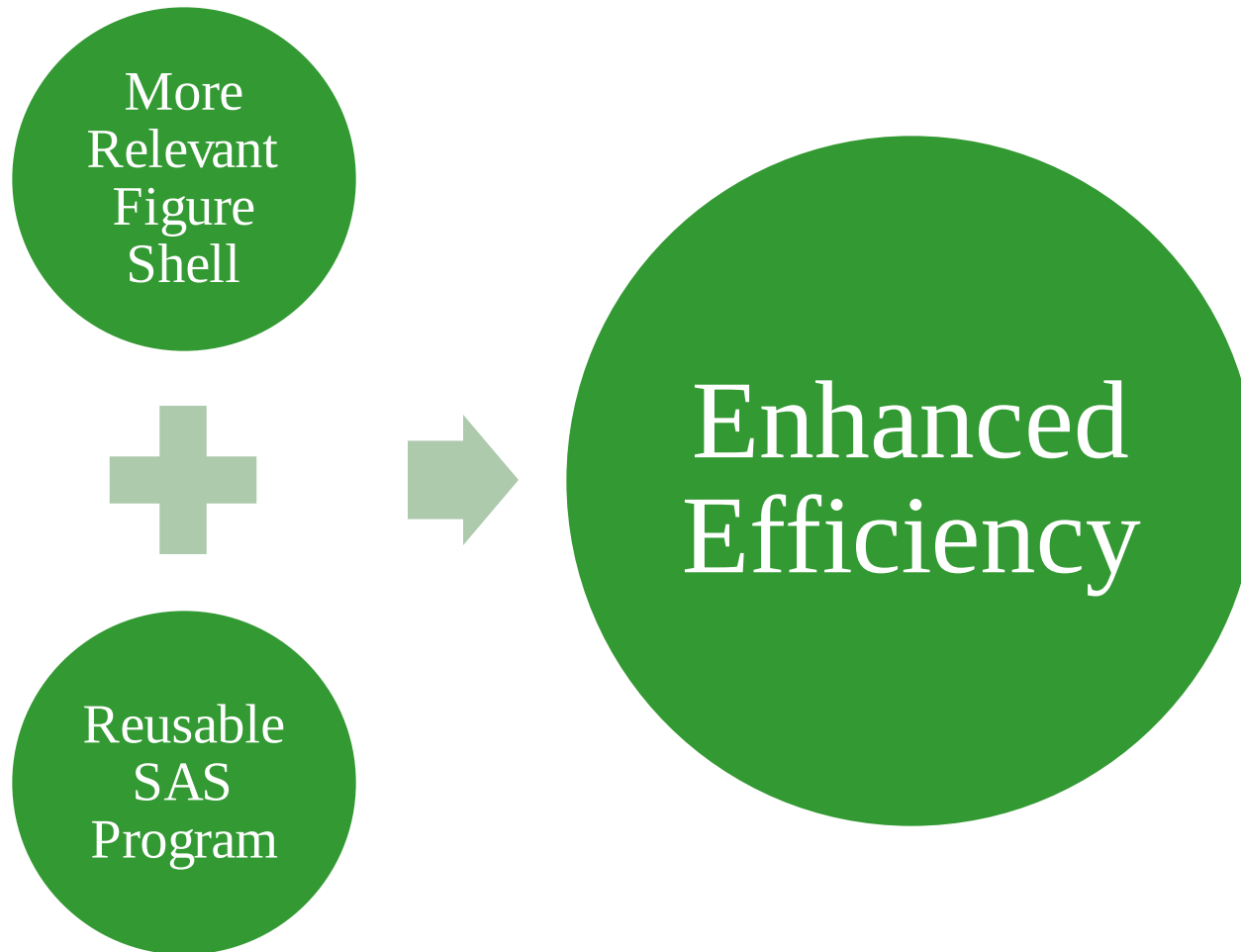
data final;
  set adam.adlb;
  where saffl='Y' and paramcd in ('ALT', 'AST') and anl01fl='Y';
  grp=trt01a;
  grpn=trt01an;
  xaxis=avisitn;
run;

GRPN=1; GRP="Placebo"; XAXIS=6; AVISIT="Visit6"; SUBJID="subject1"; AVAL=10.6465998343192; output;
595231049; output;
042630322; output;
232324973; output;
995897449; output;
264943808; output;

proc sort data = final; by grpn grp xaxis avisit; run;
proc univariate data = final noprint;
  by grpn grp xaxis avisit;
  var aval;
  output out=final2 mean=yaxis stdmean=interval;
run;
data final3; set final2; yaxisl=yaxis-interval; yaxish=yaxis+interval; run;
proc sort data = final2(where=(grpn > .)) out = grps nodupkey; by grpn; run;
data _null_;
  set grps end=eof;
  call symput ('grps'||compress(put(_n_,best12.)), trim(put(grp,$100.)));
  if eof then call symput('tot_grp', compress(put(_n_, best12.)));
run;
%macro mcl;
proc template;
  define statgraph LinePlot;
    dynamic TITLE1 TITLE2 TITLE3 TITLE4 TITLE5;
    begingraph / border=false designwidth=%sin designheight=4.8in;

```

Conclusion



References

[1] Pocock SJ, Trason TG, Wruck LM. *Figures in clinical trial reports: current practice & scope for improvement*. Trials. 2007 Nov 19;8:36. doi: 10.1186/1745-6215-8-36. rials. 2007 Nov 19;8:36.

[2] Murali Kanakenahalli, Avani Kaja. *Graphical Presentation of Clinical Data in Oncology Trials*. PharmaSUG 2015 - Paper DV10

[3] Chia PL, Gedye C, Boutros PC, Wheatley-Price P, John T. *Current and Evolving Methods to Visualize Biological Data in Cancer Research*. J Natl Cancer Inst. 2016 May 31;108(8):djw031. doi: 10.1093/jnci/djw031. Print 2016 Aug. PMID: 27245079

[4] Liqin Wang. *Graphical Presentation of Clinical Data in Oncology Studies Using R*. PharmaSUG China 2019 - Paper DV-067

[5] Pavani Potuganti, and Sree Nalluri. *Graphical Representation of Clinical Data using Heat Map Graphs*. PharmaSUG 2021 - Paper DV-078

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Work Phone: 781-354-1924

Web: <http://biopier.com/>

A close-up photograph of an hourglass with green sand. The sand is flowing from the top bulb to the bottom bulb. The hourglass is centered in the frame, and the sand is a vibrant green color. The background is a soft, out-of-focus grey.

Thank you for your time!
Any Questions?